Research Report 1446

Effects of Revised Ammunition Reloading Procedures on Reload Time for the Bradley Infantry Fighting Vehicle

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The Bradley Fighting Vehicle must be reloaded in the shortest possible time because none of the weapon systems can be fired while the turret is in the reload position. Any reduction in time affects vehicle survivability. Modifications to the Bradley's reload equipment and procedures were tested with the following results: (1) shorter reload time; (2) greater number of rounds carried; (3) fewer personnel required to perform the task; and (4) simplified training. Results indicate further tests are merited.

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Education and Training

FOREWORD

Since the early 1970s the Army Research Institute has been involved in research on the Bradley Infantry Fighting Vehicle as it has progressed through its developmental stages to and through the fielding process. As Bradleys began to be introduced to combat units, the need to evaluate tactical doctrine, operational effectiveness, and training issues in a systems context became apparent. At the request of the Deputy Chief of Staff for Training, U.S. Army Training and Doctrine Command (TRADOC), a research program was formalized among the Training Technology Agency at TRADOC, the U.S. Army Infantry School, and the Army Research Institute.

This program, performed at the Army Research Institute's Fort Benning Field Unit under Research Task 3.4.2, Advanced Methods and Systems for Fighting Vehicle Training, was designed to define emerging operational and training problems and to address the most critical issues affecting combat effectiveness. This report details some of the benefits to be derived from revised Bradley ammunition reloading procedures. Preliminary testing of these changes has begun, and some improvements to the Bradley will occur as a direct result of this testing.

EDGAR M. JOHNSON
Technical Director

EFFECTS OF REVISED AMMUNITION RELOADING PROCEDURES ON RELOAD TIME FOR THE BRADLEY INFANTRY FIGHTING VEHICLE

EXECUTIVE SUMMARY

Requirement:

To reduce the time required for a Bradley Infantry Fighting Vehicle squad to perform the reload task for the 25mm gun.

Procedure:

Modifications to the Bradley ammunition ready boxes were designed to eliminate the need to hang rounds on rails and to count the rounds as they are loaded. Prototype on-board ammunition stowage containers were designed to eliminate the cumbersome features of the present shipping containers, reduce the number of linkages, and permit stowage of a larger number of rounds with a more efficient use of space. Prototypes for both improvements were fabricated and tested. Comparisons of 25mm reload performance were obtained for the old and new ready boxes, the old and new ammunition containers, and all possible combinations of ready boxes and ammunition containers for both types of 25mm ammunition.

Findings:

Eight Bradley squads performed the 25mm reload task in combat-loaded vehicles with the result that the prototype new system simplified the current configuration to (a) greatly reduce the time requirement, (b) permit completion of the task by fewer individuals, (3) reduce training time, and (4) increase the number of rounds carried by the vehicle.

Utilization of Findings:

The prototype systems reduce the number and complexity of procedural steps required to perform the Bradley reload task, thereby resulting in potential increased operational effectiveness. The equipment redesign favorably affects individual vehicle survivability and reduces training requirements.

EFFECTS OF REVISED AMMUNITION RELOADING PROCEDURES ON RELOAD TIME FOR THE BRADLEY INFANTRY FIGHTING VEHICLE

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INTRODUCTION

In its present configuration, the Bradley Infantry Fighting Vehicle (BIFV) carries 900 rounds of 25mm ammunition in a combination of High Explosive Incendiary Tracer (HEIT or, more commonly, HE) and Armor Piercing Discarding Sabot (APDS or, more commonly AP) rounds. A single ammunition can is divided into two "ready boxes," which feed rounds directly into the 25mm gun. Space is available for 230 rounds of ammunition in the HE side, and 70 rounds in the AP side, although the boxes can be filled with either type of ammunition, depending on the mission. In addition to the 300 rounds at the ready, 600 additional rounds are stored along the sides and under the floor plates of the BIFV.

Along the left side of the vehicle, 210 rounds of ammunition are stored in 7 black plastic shipping containers, each of which contains two 15-round belts of linked ammunition. The right side of the vehicle has 6 more boxes, totalling 180 rounds. Beneath the floor on the left side of the vehicle three 30-round boxes are stored; similar storage is found under the center portion of the floor. One 30-round box is stored under the right side of the floor, adjacent to Claymore Mine storage. These 20 storage boxes contain a total of 600 rounds which, combined with the 300 rounds found in the ready boxes, provide a total of 900 rounds carried. Although unit SOP usually provides particular locations for the HE and AP boxes within the BIFV, either type of ammunition can be carried in any amount or location as described above.

As the ammunition in each of the ready boxes is being fired, a low ammunition warning light shows on the gunner's weapon control box when there are between 25 and 60 rounds of ammunition remaining in either side of the ready box. The gunner and commander must then make the decision to stop and reload, or to continue to fire until all the rounds have been expended. The reloading procedure is somewhat easier and faster if new rounds are simply linked to the last rounds which are already in the ready box; the feeder does not have to be reloaded, thus saving time. If, however, the decision is made to override the low ammo light, all rounds will be expended and a full reload must be accomplished.

The reloading procedure requires that the vehicle seek a defilade or hide position, since during the 25mm reload neither the coaxial machinegun, the 25mm gun nor the TOW missiles can be fired. Reloading is a relatively complex procedure which requires that personnel in the troop compartment unstrap and unstow the plastic ammunition boxes at both ends, remove the rounds from the boxes and then from the plastic round separators, and finally begin to link the individual 15-round belts to each other. This linking requires that a round from one belt be removed, two adjacent belts joined, and the first round reinserted to its former space. A number of linkages must be made to obtain a continuous belt of ammunition. A complete reload of the ready boxes requires 21 linkages. The newly linked rounds must then be inspected to insure that there are no misaligned rounds which would cause a misfeed at the gun.

When the required number of linkages has been made, the belts are fed into either the AP or the HE sides of the ready box. Both reloads require that the

troops in the rear and the gunner count the rounds being inserted into the ammo can so that the correct rounds can be placed atop the ready box loading rails. The troops must also remember whether to start loading with a double or a single linked round; whether to insert the rounds with the links side up or links side down; and to point the rounds in the correct direction for the type of ammunition being stored. The required procedures are opposite for HE and AP, and the number of rounds to be counted and hung on the loading rails differs for the two types of ammunition. In both cases, the BIFV must be removed from action during the entire reload process as the turret is turned from one reload position to the other, and no weapons can be fired.

BACKGROUND

Army Research Institute (ARI) researchers have observed BIFV reloading procedures and have noted the general difficulty with which troops perform this task. The black plastic ammunition shipping containers are awkward to use, do not open or reclose easily, and fingers tend to get caught in the carrying handle. The rounds must be removed carefully from the boxes; the plastic separators must be removed from each belt of 15 rounds and then replaced in the empty box or discarded. Both sides of the box must be reclosed in order to replace the empty boxes in their proper storage areas.

Observations indicate that crowded conditions within the Bradley provide a confining environment for reloading. Further complicating the problem is the fact that the ammunition which is stowed beneath the floor boards is difficult to remove when other items are piled on the floor, and when there are several people sitting in the troop compartment. Observations have also indicated that counting rounds is a laborious and often confusing process; and when the round count is lost, the reload procedure must be begun again. Since the HE and AP sides of the ready box require different numbers of rounds to be hung on the rails, further opportunity for confusion is present. The linking of rounds is a time consuming process as the 15-round belts must be combined into a long belt; the breaking and rechaining of the linkages is time consuming and often proves difficult. The continued relinking also means that linked rounds must be inspected to insure that no long or short rounds are included, lest malfunctions be induced in the feed process.

In addition to observations which have been made in the institutional training environment at Fort Benning, reports from the field indicate that these aforementioned problems combine in the field situation to make the reloading process excessively long. One such informal report included information indicating that in a competitive situation, the fastest squad, wearing winter gear and MOPP IV equipment, took 25 minutes to reload. Other times reportedly ranged up to 45 minutes. Since the BIFV cannot fire while it is reloading, these long reload times can seriously jeopardize the success of a combat mission and the survival of a squad. This long reload time requires an unrealistic form of logistical control for the platoon leader who must somehow insure that no two of his vehicles have run out of ammunition at the same time.

Based on these reports, ARI and Bradley Subject Matter Experts made some changes in the configurations of the onboard ammunition storage containers and the HE and AP ready boxes. Two new types of containers were developed, one for

the HE and the other for AP ammunition. (See Appendix B for drawings, specifications, and instructions for the new containers and modified ready boxes.) The HE onboard ammunition storage containers, of which two would be used per vehicle, are designed to fit along the right side wall of the BIFV, on the shelf, under the water container. They fit in an area presently occupied by four of the black plastic ammunition boxes. Each of these new prototype containers holds 150 rounds, prelinked into one long continuous belt. Thus, 300 rounds can be stored in an area where 120 rounds were stowed previously. The AP ammunition containers are designed to rest beneath the floor boards of the BIFV in the left and center sections. Each ammo container holds two belts or 76 rounds of ammunition. (Although the containers are herein designated AP or HE containers, any mix of ammunition can be carried on the BIFV, and the containers are therefore interchageable.)

The modifications to the HE and AP ready boxes consist primarily of removing the loading rails so that instead of the rounds being hung on rails and looped vertically, the rounds in the modified ready boxes are laid flat in overlapping horizontal rows. Besides eliminating the need to count rounds to be hung on the rails, the removal of the rails increases the number of rounds which can be fit into the box. The modified boxes hold approximately 300 rounds of HE and 90 rounds of AP ammunition, an increase over the 230 and 70 rounds respectively carried in the boxes as originally designed.

PURPOSE

The purpose of this test was to evaluate the effects of revised BIFV 25mm ammunition storage systems and reloading procedures on reloading times. Specifically to be evaluated were the comparative times of HE and AP ammunition reloading procedures using the conventional reloading procedures and equipment, as compared to the modified ready box and newly developed ammunition storage containers.

PROCEDURE

Eight BIFV squads from the 1/29 Infantry Regiment at Fort Benning were selected to participate in the reload test. Squads consisted of a "gunner" and five "dismount" troops in the back of the vehicle. Both the test vehicle with new ammunition containers and the modified ready boxes and the control vehicle with conventional containers and ready box were filled with such TO&E required equipment and weapons as missile simulation rounds, M16 rifles, bedrolls, and ammunition boxes, to provide the same crowded interior conditions as would be present in a combat situation.

Testing was conducted over a four day period, with two squads tested per day. Prior to the conduct of their tests the squads were briefed as to the general purpose of the testing, and each squad was given an opportunity to practice one iteration of the conventional reloading procedure. Squads were allowed to familiarize themselves with, but not practice with, the new containers and modified ready boxes. They were told of the locations of the "remaining" HE and AP ammunition and were told that the practice reload, although timed, would be used only for familiarization. During this initial practice the ramp was left down in order that squad interactions could be watched, to coach the squads on

proper procedures, and to indicate any errors that occurred or might occur. This was done to insure that the squads would be maximally ready to perform the conventional reload test. All squads completed the practice reload, and errors or omissions were corrected by research personnel to insure that each squad was proficient at performance of the conventional procedure.

After the preliminary practice trial, and between iterations of the testing procedure, the squads were given time to rest. A special ammunition detail was responsible for downloading the ammunition and replacing it in the ammo containers. The actual testing procedure began with all squads in MOPP IV protective equipment, but without the protective masks. They wore gloves, outer garments and boots, and were required to wear their load bearing equipment (LBE). All tests were timed, both by a timer at the ramp, and by one on the turret. The ramp of the BIFV was closed, and the troop compartment door was open to permit observer vision without permitting the troops to use the ramp area as space in which to maneuver. No coaching of the crews was permitted after the initial instructions were read.

The elapsed time was recorded by the ramp timer who announced the start time when, with the turret positioned with the gun straight ahead (6400 mils), the gunner and troops indicated that they were ready to begin. After the signal to start, the gunner traversed the turret to the HE load position (2150 mils), and the squad began the reloading process. Time was recorded when the squad announced to the gunner that the HE side of the ready box had been uploaded. The gunner then traversed the turret to the AP load position (4350 mils) where the troops began the AP upload and the timing procedure continued.

In all cases, the standard number of 230 rounds of ammunition were to be loaded in the HE ready box, although the modified ready box is capable of holding a greater number of rounds. On the AP side, 70 rounds were to be loaded. Due to the constraints provided by the ready boxes and the method for forwarding rounds to the feeder, time had to be stopped for the AP side when the box was filled and the last round was linked and ready to be forwarded to the feeder. Rounds could not be forwarded beyond this point because the plastic practice rounds available cannot be advanced to the feeder. Thus, the final 20 or so rounds which would have been in the feed chutes could not be fully inserted in the box, preventing the AP ready box door from being closed. Therefore it was determined that all timing would stop just short of that point where the next rounds must be forwarded. This method of timing was used for every squad.

Over the course of the testing procedure, each squad was given four complete reloading tasks. Half of the squads began with an iteration of the conventional reloading procedure, using the conventional black ammunition containers or boxes, and the existing ready boxes. This conventional procedure will hereafter be referred to as the OLD-OLD condition, utilizing the old ready box and the old containers. The other four squads started with the new ammunition containers and the modified ready boxes. This procedure will hereafter be referred to as the NEW-NEW condition, new ready box and new containers. After each squad performed the one reload task, it was given the other task so that each squad started either with OLD-OLD or NEW-NEW, and followed that task performance with the other condition.

In addition to the OLD-OLD and NEW-NEW reload tasks, the squads were given the opportunity to perform reloading with the new ready box and the old containers (NEW-OLD), and four squads were given the opportunity of reloading with the old ready box and the new containers (OLD-NEW). This latter test condition was somewhat difficult to perform as the interior of the Bradley must be slightly modified with some shelf supports cut out to accomodate the new containers, and this change had not been made in the vehicle with the conventional ready box. The interior of the BIFV was therefore unrealistically congested, and the condition was tested on only four squads. The order of presentation of OLD-NEW and NEW-OLD conditions was prescheduled, but the difficulties of working with limited amounts of ammunition and only two vehicles and ammunition cans forced an order of presentation based on expediency. This order of presentation was not systematic, and is not believed to have affected the test in any manner.

Finally, at the end of the test period, the squad members were given a questionnaire (See Appendix C) to elicit comment on the ready box modifications and new storage containers.

RESULTS

The statistical design was a three factor within subject factorial design with two levels of ammunition type (HE and AP), two levels of ready box (OLD and NEW), and two levels of ammunition can (OLD and NEW). Under all conditions time to reload was measured in seconds. Because data were not collected for four of the eight squads using the old ready box and new ammunition containers (OLD-NEW condition), the missing data were estimated using a correlation method. The first order linear correlations between the OLD-NEW condition and the seven other conditions were computed for the four cases having complete data. The maximum correlation obtained was between the OLD-OLD and the OLD-NEW condition, $\underline{r}$ = .823. Estimates of the missing data were obtained using the regression equation of OLD-NEW on OLD-OLD. These four estimated data points were used only in the analyses of variance (ANOVA) and planned comparisons using the eight cases. Table 1 shows the mean reload times for the eight cases data set with the exception that the OLD-NEW condition means are based on $\underline{n}$ = 4 (estimated data not included).

The experimental design for the reload test included two planned or a priori comparisons. The first hypothesis was that the NEW-NEW system total reload time would be significantly shorter than that of the existing OLD-OLD system. The second hypothesis was that the "hybrid" OLD-NEW and NEW-OLD systems would have comparable reload times. These hypotheses were tested using a planned comparisons procedure. The results indicate clearly that the complete, new reload system yields significantly less reload time (4 min. 23 sec. plus 2 min. 58 sec. or 7 min. 21 sec.) when compared to the OLD-OLD system (8 min. 3 sec. plus 4 min. 48 sec. or 12 min. 51 sec.). The question of whether the "hybrid" systems differ from one another is problematic. Using only the four cases for which NEW-OLD data was obtained, the differences in reload times are not statistically significant. However, the same comparison using the four cases plus the four estimated NEW-OLD data points shows a statistically significant difference favoring the OLD-NEW system. This result should be considered with

Table 1

Mean Reload Times (in seconds)

Ammo Type	Ready Box	Ammo Can	n	Mean	Standard Deviation	
HE	OLD	OLD	8	483.38	142.35	(8 min. 3 sec.)
		NEW	4	330.50	190.69	(5 min. 31 sec.)
	NEW	OLD	8	390.13	87.29	(6 min. 30 sec.)
		NEW	8	262.50	58.98	(4 min. 23 sec.)
AP	OLD	OLD	8	287.63	94.22	(4 min. 48 sec.)
		NEW	8	104.38	30.34	(1 min. 44 sec.)
	NEW	OLD	8	242.63	52.38	(6 min. 3 sec.)
		NEW	8	178.13	81.65	(2 min. 58 sec.)

Note. OLD-OLD system times are after 1 practice trial. NEW-NEW system times are reloads without practice.

caution, since the implication is that the OLD-NEW hybrid system could be adopted as an alternative to the NEW-OLD reload system. The statistical support for that conclusion is equivocal. Table 2 shows the planned comparisons.

The results described here indicate a number of significant findings. First, the mean time for reloading using the OLD-OLD system was compared to the mean time for reloading using the NEW-NEW system. The OLD-OLD reload time for the HE ready box, 8 min. and 3 sec., was reduced to 4 min. and 23 sec. when using the NEW-NEW reload system. This represents a 46% reduction in time. The OLD-OLD reload time for the AP ready box was reduced from a mean of 4 min. and 48 sec. to 2 min. and 58 sec. using the NEW-NEW system, a reduction of 38%. A comparison of the mean total reload time, including both sides of the ready box, showed a drop from 12 min. and 51 sec. to 7 min. and 21 sec., providing a 43% reduction in mean time while using the new system. Clearly, the combination of modified ready boxes and new amunition containers results in a dramatic time savings over the conventional reloading procedure.

Further comparisons were made between the means of the OLD-OLD system and the OLD-NEW system, to determine the effects of changing only the ammunition containers. The HE reload time dropped from a mean of 8 min. and 3 sec. to a mean of 5 min. and 31 sec., a reduction in time of 31%. The AP side showed a reduction of 63%, from a mean of 4 min. and 48 sec. to 1 min. and 44 sec. Thus the ammunition containers alone appear to effect a reduction in reload time, although in all probability the effects of the ready boxes and the ammunition containers are not independent of each other. Comparisons between the OLD-OLD

system and the NEW-OLD system, to determine the effects of changing only the ready boxes, show a much less dramatic improvement which may be attributed to chance alone.

Table 2

Planned Comparisons of Two Test Hypotheses on Total Reload Time

Comparison	df	Sum of Squares	Mean Square	F Ratio	p
		Four Cases Data Set			
NEW-NEW vs OLD-OLD	1	238388.00	238388.00	48.37	.006
Error	3	14785.69	4928.56		
NEW-OLD vs OLD-NEW	1	20661.10	20661.10	3.89	.143
Error	3	15953.69	5317.90		
		Eight Cases Data Set			
NEW-NEW vs OLD-OLD	1	218295.00	218295.00	16.18	.005
Error	7	94458.97	13494.14		
NEW-OLD vs OLD-NEW	1	105915.00	105915.00	13.82	.008
Error	7	53638.22	7662.60		

In addition to the planned comparisons described prviously, analyses of variance were performed for all three factors. Two analyses of variance were performed on reload times for four squads with complete data, and on eight squads using estimations of four missing data values. The summaries of the ANOVAs are presented in Table 3 and Table 4. Despite the small sample size associated with both analyses, the results were consistent between ANOVAs. Significant main effects were obtained for ammunition type, $F(1,7) = 37.97$, $p = .0005$, and ammunition can type (old or new), $F(1,7) = 110.59$, $p = .00001$. The effect of ammunition type merely reflects the fact that fewer rounds of AP than HE ammunition were loaded, which results in a faster reload time. The two-way interaction between ready box (old or new) and ammunition can (old or new) factors was the only interaction statistically significant for either analysis, $F(1,7) = 6.40$, $p = .039$.

Table 3

Summary of Analysis of Variance of Reload Times for Four Squads

Source	df	Sum of Squares	Mean Square	F Ratio	p
Ammo Type (A)	1	192200.00	192200.00	12.75	.0380
Error	3	45210.25	15070.08		
Ready Box (R)	1	59340.10	59340.10	6.45	.0850
Error	3	27593.13	9197.71		
Ammo Can (C)	1	199712.00	199712.00	190.43	.0008
Error	3	3146.25	1048.75		
A x R	1	28680.10	28680.10	1.28	.3410
Error	3	67445.13	22481.71		
A x C	1	0.50	0.50	0.00	.9840
Error	3	3296.75	1098.92		
R x C	1	31375.10	31375.10	8.52	.0620
Error	3	11043.13	3681.04		
A x R x C	1	741.13	741.13	0.20	.6870
Error	3	11291.13	3763.71		

Table 4

Summary of Analysis of Variance of Reload Times for Eight Squads

Source	df	Sum of Squares	Mean Square	F Ratio	p
Ammo Type (A)	1	386262.00	386262.00	37.907	.0005
Error	7	71207.75	10172.54		
Ready Box (R)	1	10050.10	10050.10	0.55	.4830
Error	7	128211.94	18315.99		
Ammo Can (C)	1	314160.00	314160.00	110.59	.00001
Error	7	19885.25	2840.75		
A x R	1	24885.10	24885.10	1.45	.2680
Error	7	120462.44	17208.92		
A x C	1	4225.00	4225.00	3.54	.1020
Error	7	8351.00	1193.00		
R x C	1	31064.10	31064.10	6.40	.0390
Error	7	33993.94	4856.28		
A x R x C	1	3751.56	3751.56	1.97	.2040
Error	7	13346.94	1906.71		

As an estimate of the minimum time required to reload using the NEW-NEW system, four squads completed three or four additional trials of reloading after the main test was complete. (See Appendix A.) This pilot testing resulted in initial information on NEW-NEW practice effects. The one-tailed T-tests presented in Table 5 indicate a statistically significant reduction in HE and AP ammunition and total reload times. Therefore, the mean total reload time of 7 min. 21 sec. obtained during the main test procedures could be expected to be reduced considerably with practice on the NEW-NEW system. The time savings of 43% is therefore a conservative estimate.

Table 5

Practice Effects on NEW-NEW Reload Times (in seconds)

	First Reload Time (no practice)		Final Reload Time (after practice)				
Condition	Mean	SD	Mean	SD	t	df	p
Total	389.75 (6 min. 30 sec.)	33.86	142.25 (2 min. 22 sec.)	16.48	16.73	3	<.0005
HE	237.50 (3 min. 58 sec.)	37.97	79.50 (1 min. 20 sec.)	15.41	8.45	3	<.005
AP	152.25 (2 min. 32 sec.)	60.33	62.75 (1 min. 3 sec.)	9.14	3.29	3	<.025

Note. Only 4 squads participated in this portion of the test.

DISCUSSION

Modified Ready Boxes and Ammunition Storage Containers

The results of this testing are meaningful in four major areas. First, with no specific training or rehearsal, squads take significantly less time to reload using the new ammo containers and the new ready box than they do with the conventional ready box and containers with which they are familiar. This time savings is important in a tactical situation. Although the times derived in this testing situation are shorter than would occur in a combat situation due to the artificiality of the conditions, it is apparent that the NEW-NEW system and procedures take a much shorter period of time than the old. Since the BIFV cannot use any of the major weapon systems while the reload is in process, the reduction in time for a complete reload is beneficial for the survival of any one squad, and in all probability, for the successful completion of a mission.

Secondly, by simply counting the number of rounds available in the two systems, the increase in number of rounds, both at the ready and stowed aboard the vehicle, is increased in the new system. The fully loaded new ready box holds approximately 400 rounds (300 HE and 90 AP), as compared to the 300 of the old box; the storage containers raise the number of rounds carried aboard the vehicle from 900 to 1142, an advantage in a combat situation.

Additionally, although no specific measurements were done in this area, it became apaprent that the new system, in addition to being faster and carrying more rounds, permits the task to be performed by fewer personnel. When using the old system, all of the people who are present can and should be utilized in some

manner, whether linking ammo or inspecting rounds or helping to unload the boxes; the time it takes to perform the reload task increases when a smaller number of people are present and able to perform the separate elements.

With the new system, the five persons in the back were never all fully utilized; in fact, it would have been very easy for two, or even one person, to have done the task in concert with the gunner. The tactical implications of this are obvious. With the NEW-NEW system, when members of the dismount team have been sent out to post security the reloading procedure would not be adversely affected by a reduction in available personnel; similarly, if the entire dismount team is out of the vehicle and the vehicle team is left to perform overwatch, the driver could easily assist the gunner in a quick reload if necessary.

Finally, a fourth area of benefit from the NEW-NEW system is apparent. The new system is very simple, and an individual without prior training could, with verbal instruction from the commander or gunner, effect the reload in a very short time. The test specifically was designed to test the NEW-NEW system without the benefit of even minimal practice. Squads were merely shown, and did not rehearse, the task of using the new system. Table 5 shows how quickly the soldiers learned to use it, as measured by the reduction in time to reload. In contrast, the conventional system is so complicated that even trained personnel have to refresh their memories by continually referring to the instructions and diagrams posted on the ammo ready box doors to prevent mistakes. In a combat situation where pressure is at a maximum and the potential for loss of one or more crewmembers is present, the ability to have the reload performed by a previously untrained person becomes very important.

Shipping Containers

As ARI began to examine the reload issue it became apparent that one of the problems associated with the reload process was that the square black plastic ammunition containers are bulky, unwieldy, and very awkward to use. A prototype box was developed for use as a possible substitute for the present boxes. (See Appendix B.)

The new shipping box is rectangular in shape and holds one 25-round belt. It can be opened from either end by releasing a latch and the linked ammunition is pulled directly from the box. This is a much simpler and faster process than that required by the old box which requires that the soldier open the box, remove one belt, remove a plastic ammunition separator, replace the separator, turn the box around, open the other end, and repeat the ammunition removal process. A further advantage of the newly designed containers is that they may be tilted or slightly pulled from the storage shelf and then emptied. This represents further time savings from the old boxes which must be fully removed from their storage spaces and returned to them after being emptied.

Since the newly designed box holds 25 rounds in one belt, the number of linkages required is reduced as the old box contained two 15-round belts which require immediate linking. Although at first inspection the smaller number may represent a loss, the space saving design of the new containers is such that a greater number of containers can be stowed in a smaller space, thus actually increasing the round stowage. The new shipping containers have not been formally

tested, but have received widespread interest. Further investigation is recommended.

CONCLUSIONS

The increased potential for operational effectiveness for the BIFV which is provided by use of the new ammunition onboard storage containers and the modified ready boxes is so dramatic that steps should be taken to insure that the new containers and ready boxes are subjected to formal full scale tests as soon as possible. The benefits provided by the combination of (1) shorter reload time, (2) a greater number of rounds per vehicle, (3) fewer personnel required for the reload task, and (4) simplicity of the new reload task itself have great implications for both tactics and training, and are worth further investigation. Ammunition containers can be fabricated locally, and very cheaply; the ready box modifications can be effected in the battalion motor pool. Initial test firings (See Appendix D) show that these modifications cause no problems in firing the weapon. Therefore, Bradley units could begin using the modified ready box and new ammunition storage containers in a timely manner.

APPENDIX A

ADDITIONAL TEST CONSIDERATIONS

In addition to the two major test conditions, two other tests were made which lend support to adoption of the new ammunition containers and modified ready boxes. Several squads were given the opportunity to perform the reload while wearing their gas masks. The reloads were performed without difficulty. Verbal reports from tested personnel indicated that although masks impeded breathing, and were irritating to the users, this problem is independent of, and in no way made more difficult by, the new reloading procedures.

A second set of post-tests involved four of the eight squads. After the initial tests were done, each squad was given two additional iterations of the NEW-NEW procedures. (One squad was given three iterations, at their own request.) In these tests, the squads were instructed to perform as quickly as possible; that they were in competition with each other.

The major result of these comparisons was to observe the very great practice effect that took place with the NEW-NEW system. During the original testing procedure the squads had been given the opportunity to inspect the new ammo boxes and cans, but had not actually practiced a reload. They were told how to do it, but had not tried the procedure. This latter series of tests then represented only the second and third trials of performance of the procedure. For each squad there was a great reduction in reload time, a learning effect that occurred as trials were repeated.

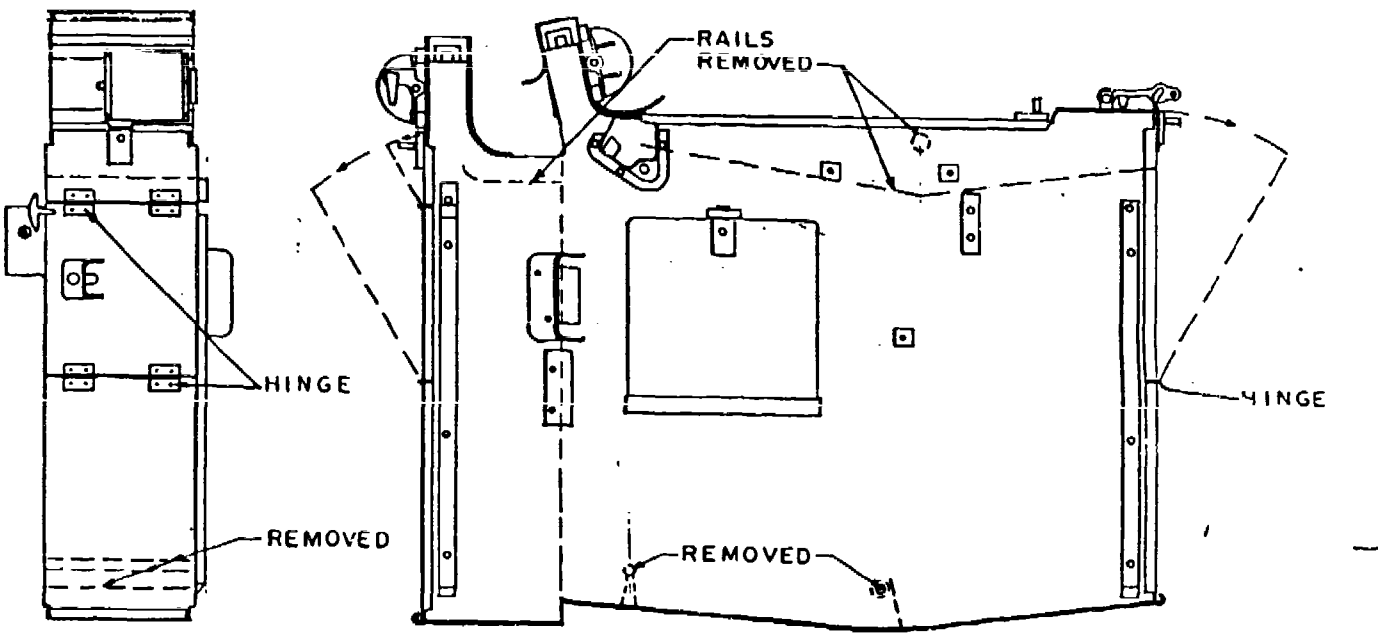
Although the absolute times would probably be longer in a real combat situation, these times may approximate the reload time. Although only one squad did three post-test iterations, and no squad performed until they had stopped improving, it is probable that they had reached almost maximum performance levels, or the minimum possible time. Although the OLD-OLD reload times would improve slightly with a number of iterations, it is unlikely that such a dramatic improvement would occur, because of the actual times required for such separate elements as linking and round counting.

APPENDIX B

DRAWINGS AND SPECIFICATIONS FOR 25mm READY BOXES, AMMUNITION CONTAINERS, SHIPPING CONTAINERS, AND COAXIAL MACHINEGUN BOXES

25mm Ready Boxes

The modified 25mm ready box for the BIFV is pictured below. The major changes which have been made from the original box involve removal of the loading rails and the floor baffles. These modifications permit the ammunition to be layered horizontally instead of being hung vertically. A small rounded baffle has been added at the top of the box to prevent the rounds from riding up if the gunner fails to install the top of the ready box after loading the ammunition. Both the HE and AP doors have been hinged, to permit easier access to the ready box, and to permit doors to be closed in sections. These modifications are easily effected in the battalion motor pool. Instructions for loading the modified ready boxes are included at the end of this Appendix.

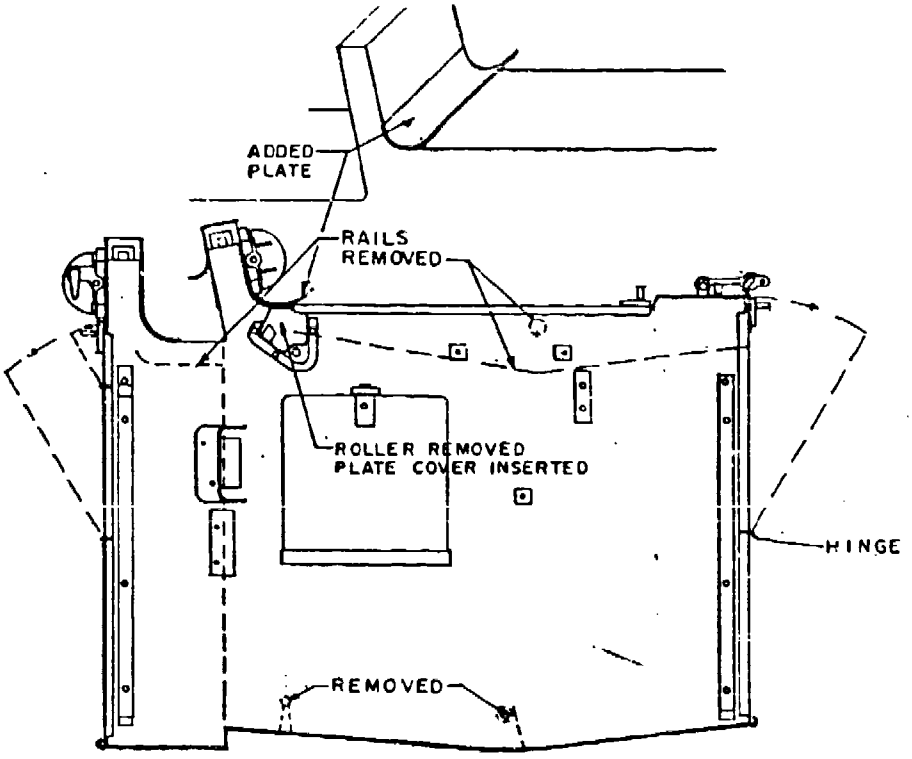


END VIEW SIDE VIEW

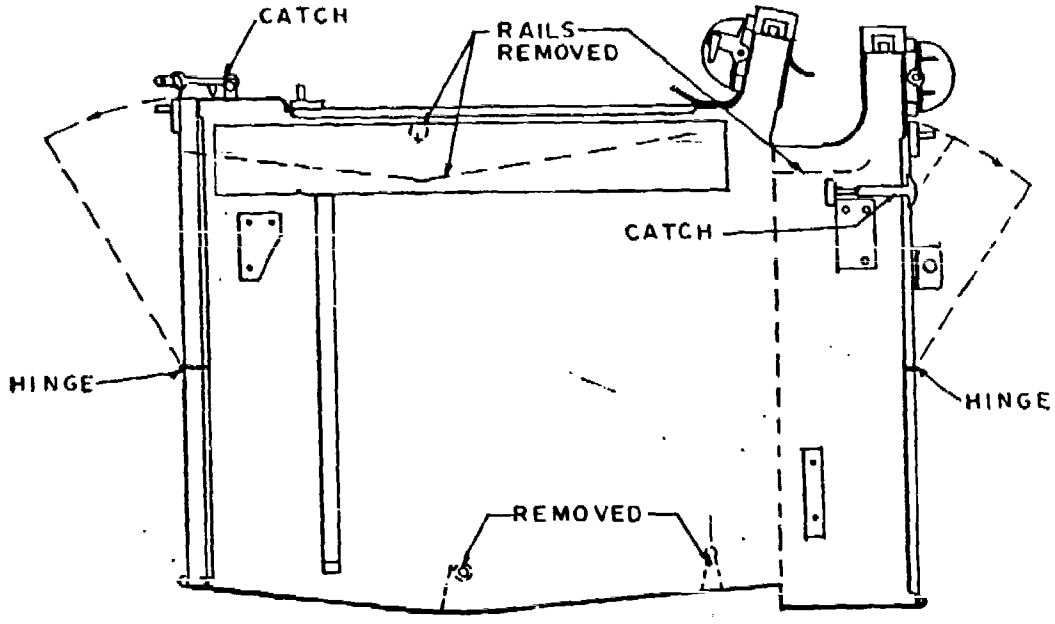
READY BOX – MODIFIED

25mm Ready Boxes, continued

Additional Changes



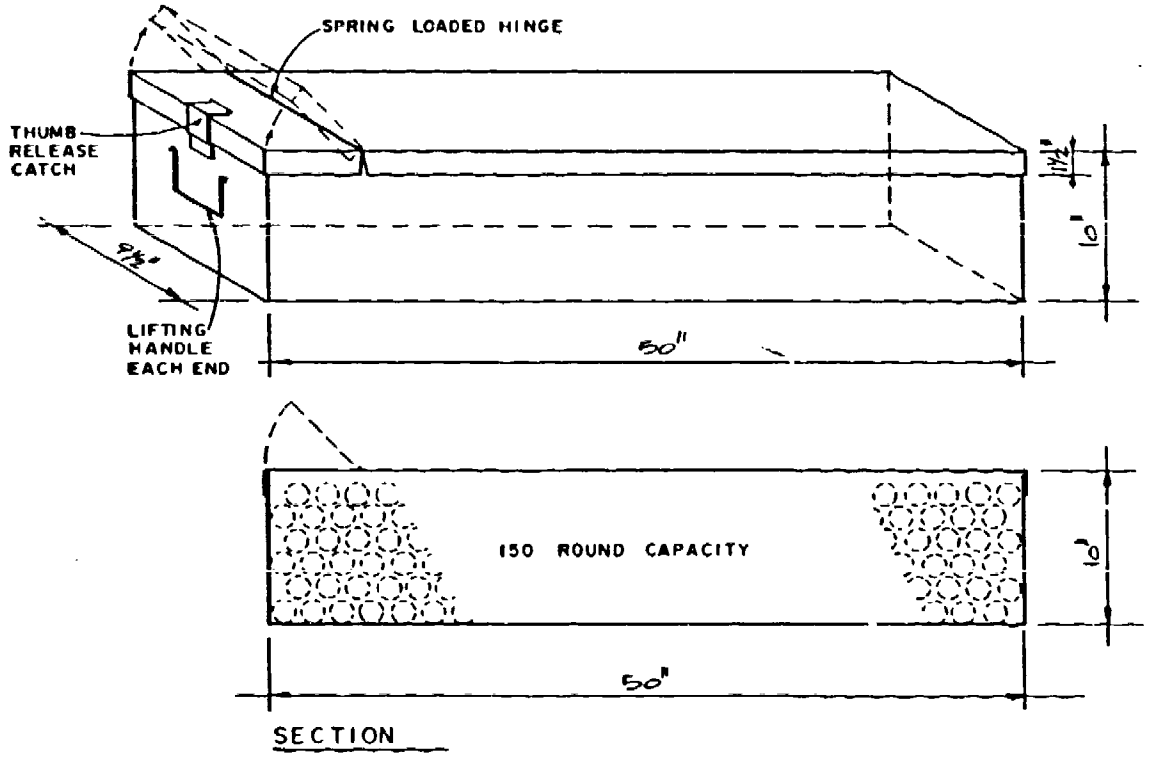
SIDE VIEW



SIDE VIEW

25mm Ammunition Storage Containers - Shelf Containers

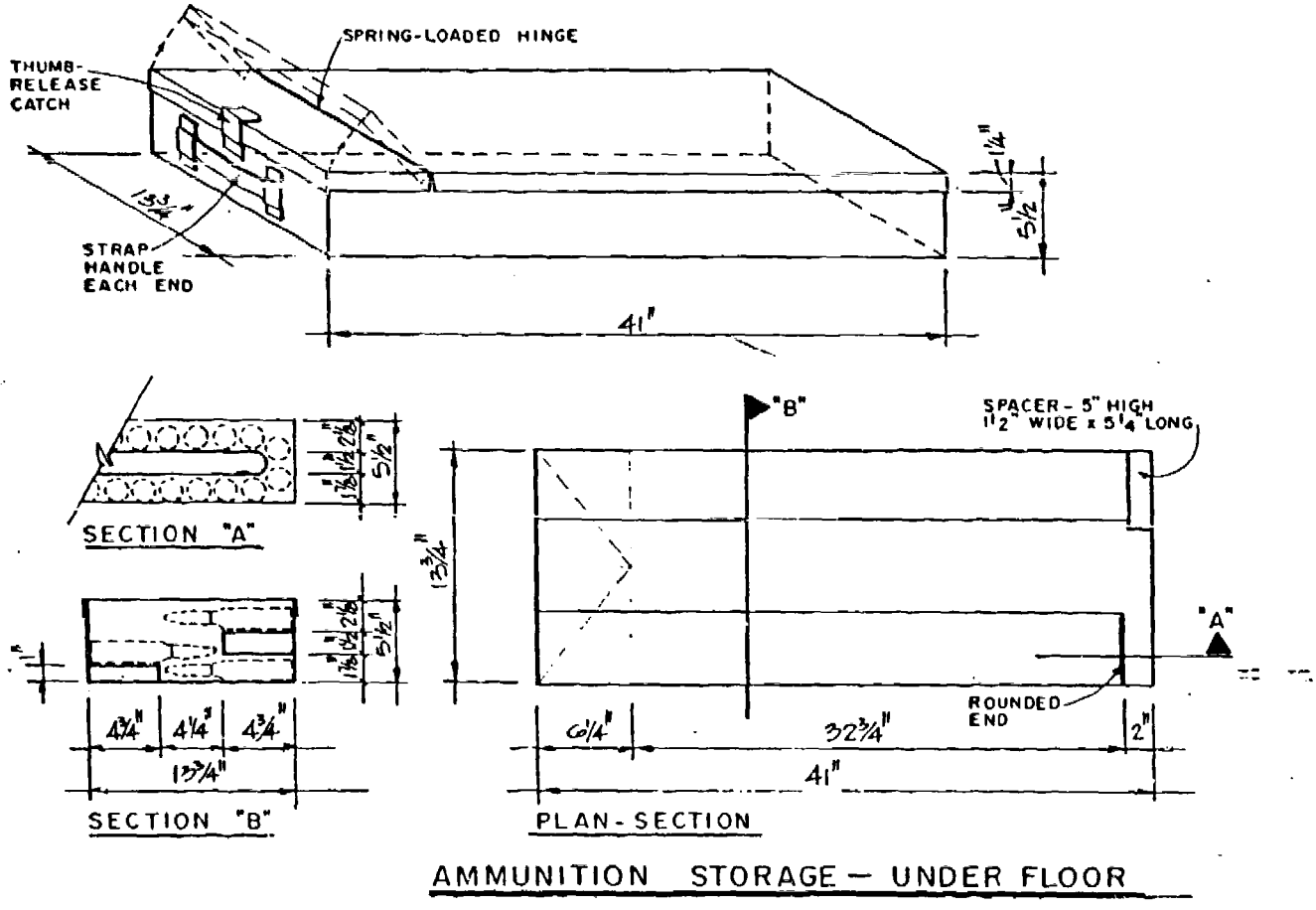
Two ammunition storage containers have been developed for the right side shelf of the BIFV. Each of the boxes contains a 150 round belt of prelinked 25mm ammunition. The boxes are placed next to each other on the shelf, with the open end toward the turret. Removing the ammunition requires only that the box be slid from the shelf on the number 8 and number 9 seats and the ammunition pulled out and placed in the ready box. These containers are pictured below. Instructions for loading the ammunition into these containers, and from them into the ready box, are included at the end of this Appendix.



AMMUNITION CONTAINER — SHELF

25mm Ammunition Storage Containers - Under Floor Containers

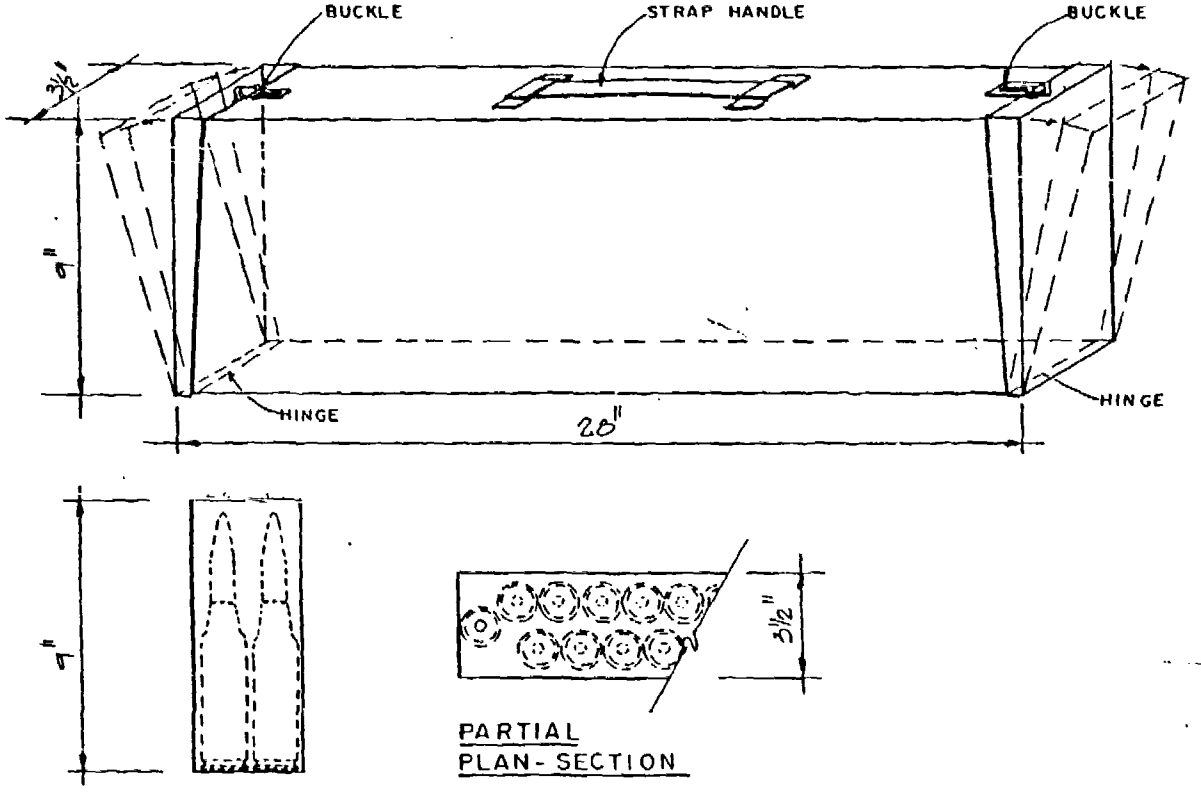
Two ammunition containers have been developed for the under-the-floor storage space in the BIFV. Each of the boxes contains 76 rounds of ammunition, in two 38-round belts. Removing the ammunition requires that the floor plate (modified to include a hinge) be lifted, the box top be opened, and the ammunition belt be pulled from the box. When the first belt has been removed, the second belt is removed and linked to the first. These containers are pictured below. Instructions for loading the ammunition into these containers, and from them into the ready box, are included at the end of this Appendix.



AMMUNITION STORAGE — UNDER FLOOR

25mm Ammunition Shipping Containers

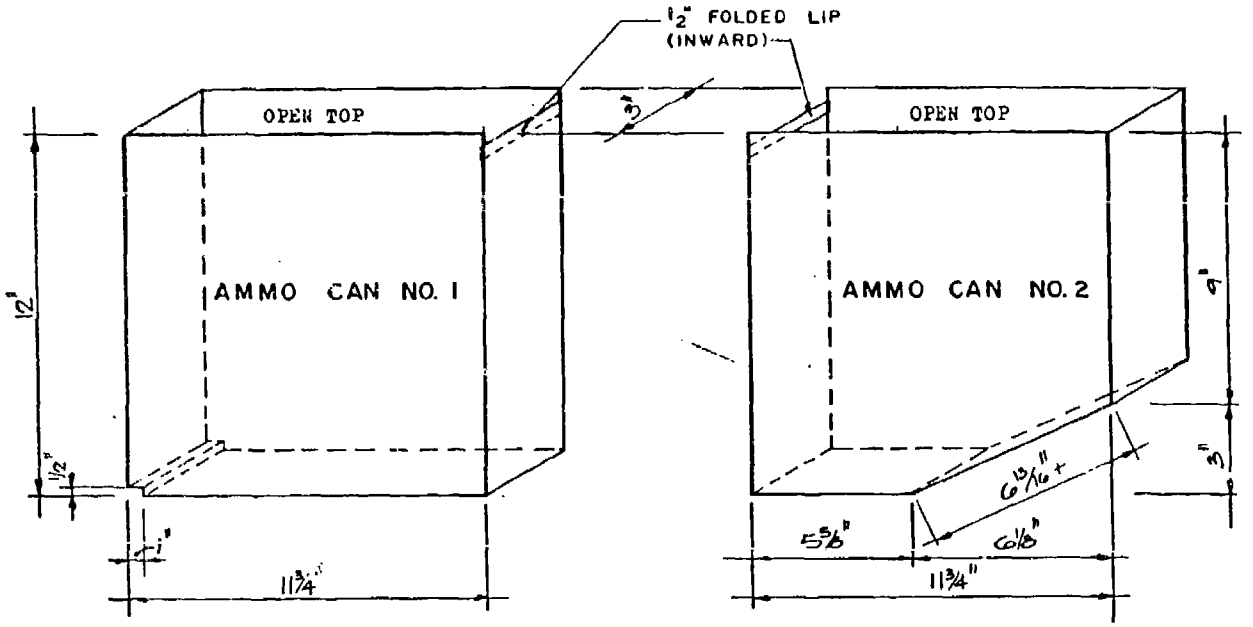
A new 25mm ammunition shipping container has been developed for use in the side shelves of the BIFV. Each container holds 25 prelinked rounds and three containers fit in the space of two of the standard black boxes; thus 75 rounds are carried in the space of 60, and the number of linkings is reduced. The container is simpler to use than the old box. Only one end of the box (either end) has to be opened, and the container can be rotated on the shelf and emptied, instead of being removed completely. This container is pictured below.



SHIPPING CONTAINER

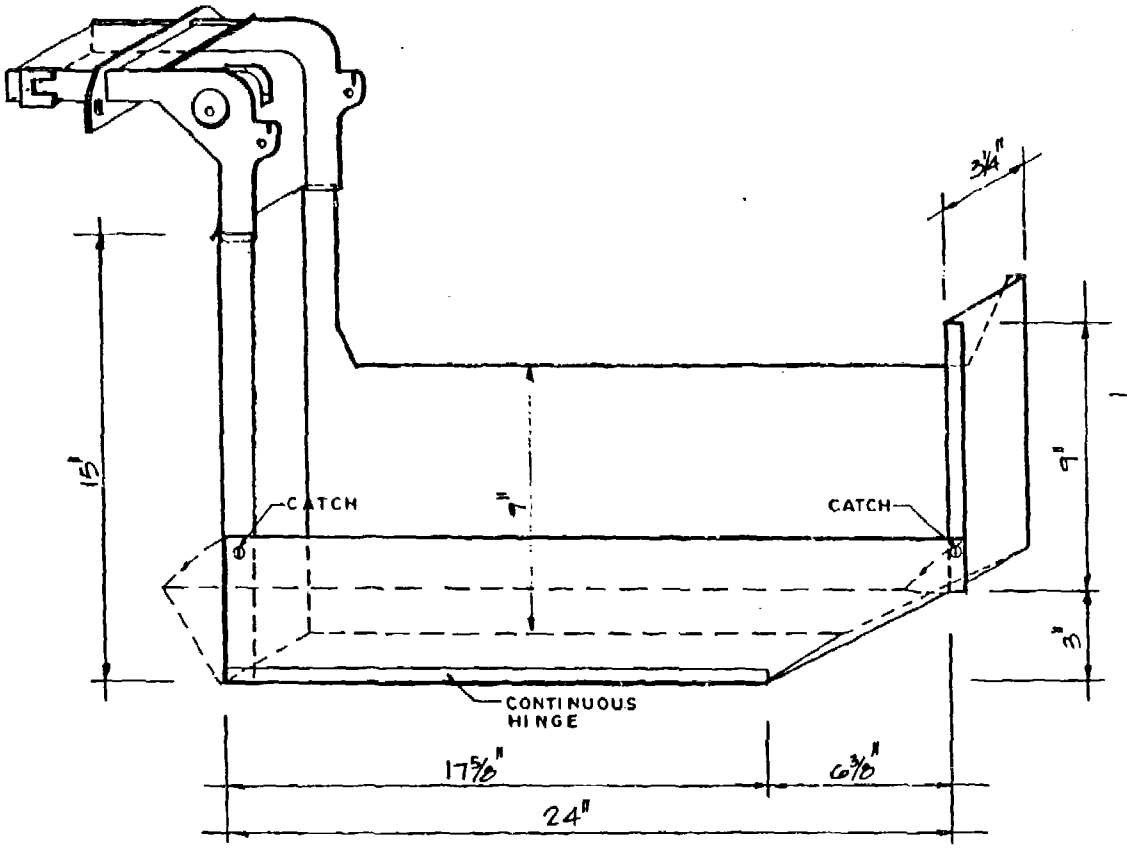
Coaxial Machinegun Ready Box Modification

A new ready box has been developed for the coaxial machinegun for the BIFV. The new ready box is straight, rather than curved, and consists of a frame with two removeable ammunition containers. Each of the two cans holds approximately 450 rounds of 7.62 ammunition. The cans can be filled in the troop compartment, and passed to the gunner as needed. The cans, the frame, and the cans within the frame are pictured below and on the next page.

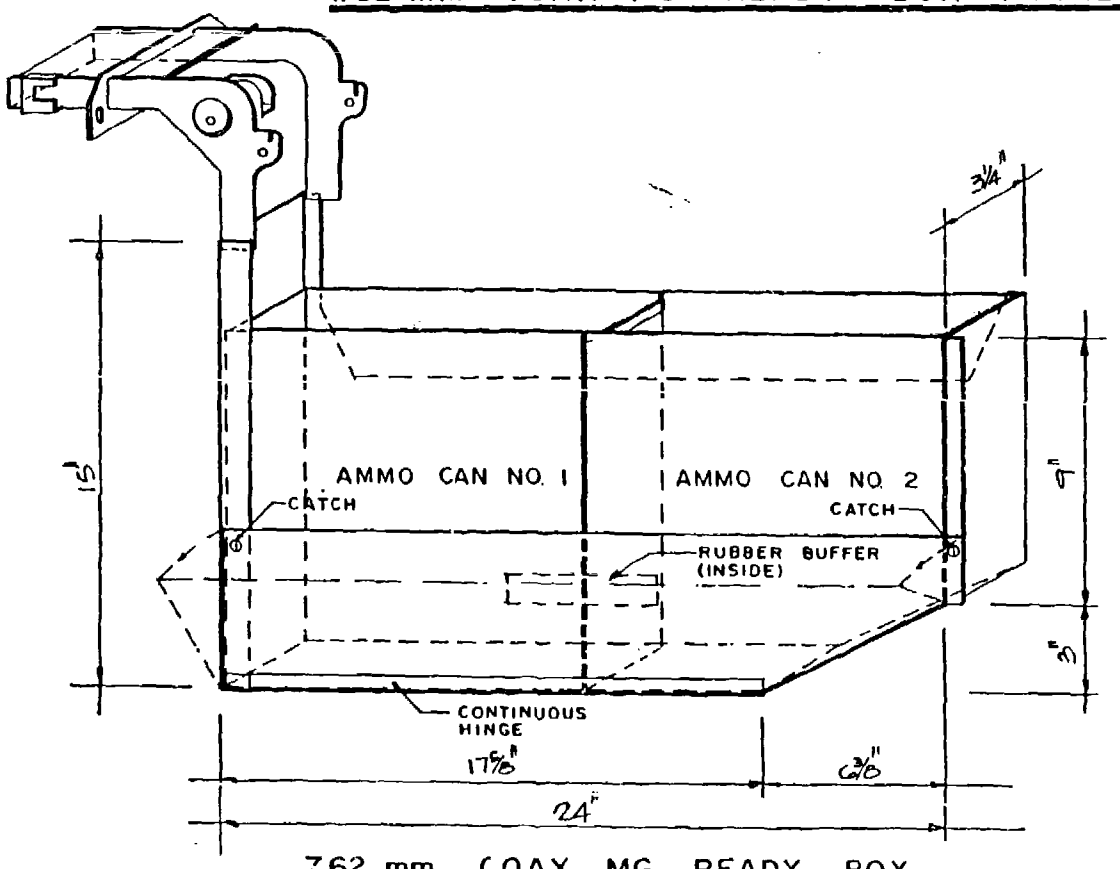


AMMUNITION CANS

7.62 mm COAX FEED SYSTEM



7.62 mm COAX MG READY BOX FRAME



7.62 mm COAX MG READY BOX

Loading Instructions for Shelf (HE) Ammunition Containers

To load ammo container:

Place belt into container starting with a double linked round, link side up. Loop ammo back and forth ending with a single linked round.

To load ready box:

Pull ammo belt straight out from container. Place a single linked round in bottom of far side of ready box. Loop ammo back and forth ending with a double linked round. Link second belt to first and continue to loop, ending with a double linked round.

To start to load feeder:

Starting with a double linked round, forward belt to the feeder, links up, with rounds pointed to right of vehicle.

Loading Instructions for Floor (AP) Ammunition Containers

To load container:

Place first belt into container starting with a single linked round, link side up. Loop belt so that it folds over on itself, ending with a double linked round, link side down. Place second belt into container, starting with a single linked round, link side up. Loop belt over the baffle so that it folds over on itself, ending with a double linked round, link side down.

To load ready box:

Pull ammo belt straight out from container. Place a double linked round in bottom of far side of ready box. Loop ammo back and forth, ending with a single linked round. Link second belt to first and continue to loop, ending with a single linked round.

To start to load feeder:

Starting with a single linked round, forward belt to the feeder, links down, with rounds pointed to left of vehicle.

Loading Instructions for Coaxial Machinegun Ready Box

Place first belt into container and hold double linked round at top of can. Drop vertical row, links down, then overlap belts horizontally until can is filled. Single link will go to feeder with rounds pointing to right side of vehicle. Load both cans identically.

APPENDIX C

USER QUESTIONNAIRE

Each of the test subjects was given the opportunity to answer a questionnaire at the conclusion of the testing procedures. A sample of the questionnaire is reproduced below, with summary data of the results as appropriate. Generally, however, the test personnel were very positive about the new ammunition containers and the modified ready boxes, and they felt that they would benefit the BIFV loading procedures.

1. Do you think the new ammo cans will save time in reloading? Why or why not?

Yes - 48 No - 0 No Answer - 1

2. Would you like to see the new ammo cans adopted for use in your unit?

Yes - 45 No - 2 No Answer - 2

3. Do you think the modified ready box will reduce the time it takes to reload?

Yes - 43 No - 3 No Answer - 3

4. Do you see any problems which might occur when using the modified ready box or ammunition cans? Be specific.

Water seepage; cans too big, too heavy, need rollers; too much weight on feeder

5. Do you have any better ideas for ammo storage? We are open to your suggestions.

Latches should be installed on containers; locking lids; need lights in ready box for gunner

6. Did wearing MOPP or winter gear make reloading harder?

Yes - 26 No - 19 No Answer - 4

Several commented that gloves ripped on ready box.

APPENDIX D

REPORT OF LIVE FIRE DEMONSTRATIONS

25mm Live Fire Demonstration

A month after the initial testing was performed, a live fire demonstration was conducted utilizing the modified 25mm ready boxes and a modified coax ready box (See Appendix B for specifications). Although the new 25mm ready box had been previously test fired on a preliminary basis, a full 1020 rounds were fired from the vehicle on Red Cloud Range at Fort Benning, utilizing both the HE and the AP modified ready boxes using TPT ammunition. Firing was accomplished from stationary positions after a series of jumps. The jumps were made to determine if the ammunition would shift within the ready boxes during movement, and to determine if the ammunition storage containers and their contents would remain stable.

The only malfunction which occurred was as a result of primer accumulation in the bolt and track assembly, and a misaligned round. The latter problem is a common cause for malfunction and is due to operator error; the former problem, called a dry bolt seizure, was a result of the nearly 900 rounds that had been fired before the malfunction occurred. The malfunction was reduced by on-site Master Gunners, and was determined to have been in no way attributable to the ready boxes. Throughout the entire firing both the ready boxes and 25mm ammunition containers performed satisfactorily.

Coax Machinegun Ready Box

Also tested during the live fire demonstration was an improved ready box for the coax machinegun. The conventional box, designed as a curved structure with two interior baffles, is very awkward to fill. The Bradley Commander must reach up and to his right to load the three compartments of the coax box by feel as he cannot see the interior of the box. The complete process of reloading reportedly takes from six to eight or more minutes. The box holds 800 rounds of 7.62 ammunition.

The modified coax ready box has straight sides and the interior has been modified. Instead of the three-section box, the new ready box consists of an exterior framework which holds two separate ammunition cans. These cans may be removed from the frame itself and can be filled independently of each other. Troops in the troop compartment can refill the cans with belted ammunition. The cans are stored in the troop compartment or in the turret and replaced in the framework as needed. Each of the two cans holds 450 rounds; a second pair of cans is available at the ready for resupply when necessary. The entire reloading process consists of replacing the two cans and performing the one linkage required to join the 450 round belts; the task can easily be performed in less than a minute.

The modified coax ready box was subjected to preliminary firing on Red Cloud Range and 2400 rounds of 7.62 ammunition were fired. No problems were observed and no malfunctions were attributable to the newly designed ready box. There were no stoppages, and no difficulties with the ammunition feed system.

Test Procedures

The purpose of the live firing demonstration was to determine whether the proposed modifications to reload procedures could withstand the rigors imposed by rough terrain maneuver of the BIFV. This testing provided observations on (A) the ready boxes, (B) the ammunition containers, and (C) the modified coax box. The procedures followed are detailed below. An asterisk indicates that the ammunition was inspected and unusual findings (if any) were recorded.

Task A:

*1. Load 25mm ready box, both sides.
2. Perform cross country driving test and "jump" BIFV.
*3. Fire one half of the ammo from each side.
4. Perform cross country driving test and "jump" BIFV.
*5. Fire aother quarter of the ammo from each side.
6. Perform cross country driving test and "jump" BIFV.
*7. Fire balance of load.

Task B:

1. Load ammo containers for deck and shelf.
2. Perform cross country driving test and "jump" BIFV.
*3. Remove one third of ammo from each box.
4. Perform cross country driving test and "jump" BIFV.
*5. Remove another one third of ammo from box.
6. Perform cross country driving test and "jump" BIFV.
*7. Perform final ammo check.

Task C:

1. Load coax chute and ready box.
*2. Fire first ammo can.
3. Replace can and relink ammo.
*4. Fire complete sequence of ammo through both cans.